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CONTENTS

	PAGE
Standardization Committee: Reports of Sub-Committees	25
Practical Alignment Chart for Fluid Flow in Pipe-lines. By P. Meyer	52
Abstracts	55A
Books Received	102A
Institute Notes	i–ii

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STANDARDIZATION COMMITTEE.

REPORTS OF SUB-COMMITTEES.

REPORTS of the various Sub-Committees are published in this issue of the *Journal* in order to give members an account of the work done during the past year 1942–1943. Much of this work has resulted in modifications and additions to "Standard Methods for Testing Petroleum," but, in addition, all the various Sub-Committees and their Panels had under consideration other modifications and methods of test. This has involved in some instances co-operative work in many laboratories. Such work will result in improvements which may be incorporated in the next and following issues of "Standard Methods."

It is the desire of the Standardization Committee in these annual reports to keep members informed not only of the work done, but also of the trend of future work; it will welcome offers of co-operation which may make future editions of "Standard Methods" of increasing usefulness both to the petroleum industry and to users of petroleum products.

REPORT OF SUB-COMMITTEE NO. 1—MEASUREMENT AND SAMPLING.

1. ORIGIN OF COMMITTEE, ITS SCOPE AND PRESENT COMPOSITION.

The Committee, which was originally known as the "Measurement of Oil in Bulk Committee," was formed early in 1931. Mr. J. Kewley had for some time been convinced that the lack of standardization in methods appertaining to the commercial measurement of bulk quantities of liquid petroleum products was something to be deplored, and he persuaded the Institute to set up a section of its Standardization Committee with "the standardization and unification of methods and equipment used in the measurement of bulk petroleum products" as its terms of reference.

The Committee was reorganized three years ago, when, in addition to an extended personnel, its work was divided among a series of Panels. The present Committee and the seven associated Panels are constituted as follows:—

SUB-COMMITTEE I.

H. Hyams (*Chairman*) (Asiatic Petroleum Co., Ltd.).
P. Docksey (Anglo-Iranian Oil Co., Ltd.).
E. B. Evans (Anglo-American Oil Co., Ltd.).
T. L. Evans (Shell Refining and Marketing Co., Ltd.).
F. H. Garner (Birmingham University).
A. W. Higson (Petroleum Board).
M. H. Hoffert (Anglo-Iranian Oil Co., Ltd.).
W. F. Jelffs (B. & R. Redwood, Ltd.).
P. Kerr (Asiatic Petroleum Co., Ltd.).
J. Kewley.
A. Osborn (Esso European Laboratories).
E. Stokoe (Shell Refining and Marketing Co., Ltd.).
G. D. Thacker (Shell Refining and Marketing Co., Ltd.).
W. H. Thomas (Anglo-Iranian Oil Co., Ltd.).
F. Tipler (Petroleum Board).

Panel I.—Calibration of Tanks.

F. Tipler (*Chairman*) (Petroleum Board).
A. W. Higson (Petroleum Board).
W. F. Jelffs (B. and R. Redwood, Ltd.).
P. Kerr (Asiatic Petroleum Co., Ltd.).
E. Stokoe (Shell Refining and Marketing Co., Ltd.).

Panel II.—Measurement of Oil Depths.

E. Stokoe (*Chairman*) (Shell Refining and Marketing Co., Ltd.).
P. Docksey (Anglo-Iranian Oil Co., Ltd.).
G. W. W. Ford (Stemco, Ltd.).
A. W. Higson (Petroleum Board).
M. H. Hoffert (Anglo-Iranian Oil Co., Ltd.).
A. Osborn (Esso European Laboratories).
W. H. Thomas (Anglo-Iranian Oil Co., Ltd.).
F. Tipler (Petroleum Board).

Panel III.—Sampling.

W. F. Jelffs (*Chairman*) (B. and R. Redwood, Ltd.).
J. E. Byles (Board of Customs and Excise).
E. B. Evans (Anglo-American Oil Co., Ltd.).
G. W. Lepper (Ministry of Fuel and Power).
J. Mason (Ministry of Aircraft Production).
F. H. Newington (Admiralty).
A. Osborn (Esso European Laboratories).
G. D. Thacker (Shell Refining and Marketing Co., Ltd.).

Panel IV.—Temperature Measurement.

G. D. Thacker (*Chairman*) (Shell Refining and Marketing Co., Ltd.).
P. Docksey (Anglo-Iranian Oil Co., Ltd.).
T. L. Evans (Shell Refining and Marketing Co., Ltd.).
E. Stokoe (Shell Refining and Marketing Co., Ltd.).
W. H. Thomas (Anglo-Iranian Oil Co., Ltd.).

Panel V.—Gravity Measurement.

E. B. Evans (*Chairman*) (Anglo-American Oil Co., Ltd.).
T. L. Evans (Shell Refining and Marketing Co., Ltd.).
A. Osborn (Esso European Laboratories).
W. H. Thomas (Anglo-Iranian Oil Co., Ltd.).

Panel VI.—Units of Measurement, Calculations and Tables.

P. Kerr (*Chairman*) (Asiatic Petroleum Co., Ltd.).
E. B. Evans (Anglo-American Oil Co., Ltd.).
M. H. Hoffert (Anglo-Iranian Oil Co., Ltd.).

Panel VII.—Oil Measurement Apparatus.

W. F. Jelffs (*Chairman*) (B. and R. Redwood, Ltd.).
T. L. Evans (Shell Refining and Marketing Co., Ltd.).
G. W. W. Ford (Stemco, Ltd.).
A. W. Higson (Petroleum Board).
E. Stokoe (Shell Refining and Marketing Co., Ltd.).
W. H. Thomas (Anglo-Iranian Oil Co., Ltd.).

2. Work already Published.

(a) *Weights and Measures.*—The Committee first devoted its attention to the clearing up of the misunderstandings that existed in the industry because of the absence of authoritative conversion ratios for the various units of weight, volume, and capacity in the metric, Imperial (British), and American (U.S.A.) systems. The Institute's publication "Measurement of Oil in Bulk, Part I—Standard Weights and Measures," published in 1932, was the result. The table of Inter-Relation of Units and the

recommended Contracted Ratios contained in the booklet are now widely recognized because of their up-to-date legal and scientific basis. The A.P.I. paid the Committee the compliment of accepting these tables on behalf of the American oil industry.

(b) *First World Petroleum Congress.*—The Committee took a very active part in this London Congress, held in 1933. It accepted responsibility for the collection and presentation of a series of papers on oil measurement, which formed a section of the deliberations of the Congress. Three members of the Committee presented the following papers :—

"The Measurement of Oil by Volume," by J. McConnell Sanders.
"The Calibration of Receptacles used for the Storage, Transport and Distribution of Petroleum and its Products," by W. F. Jelffs.
"Hydrometers and Hydrometry," by Verney Stott.

(c) *Measurement of Oil by Volume.*—The interest aroused by Mr. McConnell Sanders' paper on this subject at the First World Petroleum Congress led to the decision by the Institute to hold a special meeting for the further ventilation of views. Accordingly, on 28th June, 1934, Mr. McConnell Sanders presented another paper on behalf of the Oil Measurement Committee, entitled "On the Advantages Secured by Expressing Quantities of Liquid Petroleum in Terms of Volume or Capacity rather than of Weight." [1] This paper strongly urged the exclusive use of measurement of oil by volume in commercial transactions, but in spite of overwhelming support and the unanimous decision of the meeting to work for the international standardization of volume measurement, no marked progress towards this ideal appears to have been made since 1934.

(d) *Coefficients of Expansion.*—In 1936 the Committee began a study of the tables and methods which were in use in the industry for the correction of volumetric quantities and specific gravity for temperature change. In 1937 it was decided to collect data on this subject from as many sources as possible. The collation of the material sent in was a considerable task; the outbreak of hostilities retarded progress, but in 1941 the results were produced in the *Journal* in the form of a report entitled "Expansion of Crude Petroleum, Petroleum Products and Allied Substances." [2] The conclusions were interesting. They showed that the results of the investigational work which had been carried out by the American Bureau of Standards in 1912–1915, on the oils then available, were still widely applicable in 1941. Thus, the volume and gravity correction tables contained in the Bureau's Circular C.410, whilst having certain limitations, could be recommended for general adoption. Certain materials would have to receive special treatment, but, in general, there was no justification for new and extended investigational work with the object of preparing a new set of tables.

(e) *Second World Petroleum Congress.*—The participation of the Committee in the Paris Congress of 1937 took the form of two papers, one on "Standard Weights and Measures" presented by Mr. Hyams on behalf of the Committee, and the other in Mr. Hyams' own name on "Volume

[1] *J. Inst. Petrol. Tech.*, 1934, **20** (129), 665–688.
[2] *J. Inst. Petrol.*, 1941, **27** (215), 402–417.

Correction Tables in the Commercial Measurement of Liquid Petroleum Products." The first paper emphasized the need for the publication and the international use of authoritative tables of conversion ratios in the petroleum industry, and gave extracts from and comments on the I.P. booklet on Weights and Measures. The second paper summarized and commented on the work which had been published on this subject, and concluded that Table 2 of U.S. Bureau of Standards Circular C.410 was " worthy of universal acceptance because of its authoritative nature and the need for standardization "; and that " there is a need for tables, both in the Imperial and in the metric system, corresponding to Table 2 of U.S. Bureau of Standards Circular C.410."

(f) *Specific Gravity and Sampling.*—Of the methods of test covered by I.P. " Standard Methods," Sub-Committee I is responsible for Specific Gravity and Sampling. The Specific Gravity method was very largely rewritten and extended in the 1942 edition; the form in which the method now appears will, it is hoped, make it possible for the recommended procedure for the specific gravity determination of any product to be easily consulted and applied. In the next edition of " Standard Methods " the alterations to this method have been relatively minor; a method for specific gravity determination of liquefied petroleum gases has been included, and specifications for hydrometers have been substantially altered.

The Sampling Method, both in the I.P. and A.S.T.M. Standard Methods, has remained unchanged for some 10 years. Sub-Committee I decided on a complete revision both of material and set-up. The results will appear in the next edition of I.P. " Standard Methods," and are submitted as simplified and modernized procedures for the sampling of all types of petroleum products from every normal type of container.

(g) 60° *F. as Standard Reference Temperature.*—Action which was contemplated by the I.S.A. (International Federation of National Standardizing Bodies) just prior to the outbreak of the war made it necessary for the Institute to define its attitude both on the question of the standard method of reporting the specific gravity of a petroleum product and on the standard temperature to which volumes of bulk products should, when necessary, be corrected. The I.S.A. apparently favoured density in terms of grammes per ml. at 20° C., and 20° C. also as the standard reference temperature for oil volumes. Sub-Committee I in a note entitled *Standard Temperature for Specific Gravity Determination and Volume Correction*[3] made it clear on behalf of the Institute that specific gravity 60° F./60° F. was the specific gravity basis recommended by the I.P.; and that 60° F. was the temperature favoured and laid down by the Institute both for reporting specific gravity results as well as for correcting volumes of liquid petroleum products. In these matters the Sub-Committee made it clear that the Institute was perfectly in step with the A.P.I. and the A.S.T.M.

3. Co-operation with the A.S.T.M.

Exchanges of views in 1938 between the chairmen of the I.P. Measurement and Sampling Committee and A.S.T.M. Committee XV on Sampling

[3] *J. Inst. Petrol.*, 1943, **29** (235), 190–191.

and Gaging indicated that there was a common feeling that the subject of oil measurement was of sufficient importance to warrant steps being taken for a complete interchange of information with the object of securing uniformity in method and procedure. Close co-operation between the two Committees has been maintained ever since, in spite of war-time difficulties. Both Committees have a series of closely similar Panels which are charged with the detailed work.

Full exchange of draft proposals, in their earliest stages, takes place between the two Committees. There is agreement on the desirability of joint production of A.S.T.M./I.P. methods and views, wherever this is possible. A document on "Principles" relating to oil measurement has been produced by our Committee, and it is hoped that it will, before very long, be the first of the joint publications by the two organizations. We have also prepared a statement and a series of tables for the conversion of metric tons (*in vacuo*) to long tons and short tons (*in air*). The correct conversion of the one type of weight to the other has created difficulties in the computation of bulk petroleum products, and a joint pronouncement with our American friends is being sought. Further, difficulties in the preparation of a standard method for calibration of oil-storage tanks, and in the correlation of weight and volume tables (under preparation by our Panel VI), with tables published by Bureau of Standards, are being fully discussed with the American standardizing bodies.

In every respect, therefore, the co-operation with our American friends in the sphere of standardization work on oil measurement can be regarded as being very active.

4. Work Contemplated.

The work of the Panels proceeds as speedily as war-time conditions permit. The intention is that the results produced by all the Panels shall eventually be dovetailed into one comprehensive work on oil measurement, the function of the Committee then being to keep the work up-to-date. Obviously, however, one Panel may progress faster than the others, so that its work will be available for publication earlier. Sampling has already been dealt with, but will have to be specially applied, and in greater detail, to quantity measurement. Tank calibration is receiving very active attention, and, when initial difficulties have been overcome, should result in an official publication on this subject—possibly a sister booklet to the one on Weights and Measures. Panel VI on Tables is engaged on the task of preparing a set of tables as follows :—

(*a*) A table of volume correction factors based on Table 2 of U.S. Bureau of Standards Circular C.410 but entered against specific gravity 60° F./60° F. instead of against ° A.P.I. at 60° F.

(*b*) Tables giving weight per unit volume and volume per unit weight, similar to Table 4 of Circular C.410 but entered against specific gravity 60° F./60° F. and giving

(i) Lbs. per Imperial gallon.
(ii) Long tons per Imperial gallon.
(iii) Imperial gallons per long ton.

These tables will possibly be published individually as they become available, but the programme undertaken by the Sub-Committee will, it is hoped, result in the production of a book of tables, authoritative in nature and widely applicable in the industry in connection with the quantitative measurement of bulk oil.

REPORT OF SUB-COMMITTEE NO. 2—CRUDE OIL.

The Sub-Committee on Crude Oil consists of the following :—

SUB-COMMITTEE 2.

G. H. Coxon (*Chairman*) (Anglo-Iranian Oil Co., Ltd.)
B. C. Allibone (Burmah Oil Co., Ltd.).
E. J. Boorman (Government Laboratory).
C. Dalley (Trinidad Petroleum Development Co., Ltd.).
A. G. Forbes (Agwi Petroleum Corporation, Ltd.).
G. W. Lepper (Ministry of Fuel and Power).
R. I. Lewis (Asiatic Petroleum Co., Ltd.).
H. E. L. Pracey (Asiatic Petroleum Co., Ltd.).
A. R. Stark (Anglo-Iranian Oil Co., Ltd.).
W. H. Thomas (Anglo-Iranian Oil Co., Ltd.).

Before embarking on the evolution of a crude-oil evaluation the Sub-Committee made a survey of existing methods, and also contacted the corresponding Committee of the A.S.T.M. in the United States, who intimated that they are not at the moment contemplating the issue of any crude-oil assay.

In the earlier consideration of the crude-oil evaluation method the Committee considered that the information desired fell best under two headings : (1) a short sorting inspection and (2) a detailed evaluation. As now proposed the first inspection uses existing apparatus and test methods with few modifications, and is considered to be sufficient to allow comparison to be made between, for instance, successive cargoes of crude-oil receipts, or between a crude sample as offered for sale and the actual cargo receipt. The second, more detailed, evaluation requires specialized apparatus and technique, but in the consideration of this evaluation the Committee has tried to balance the scope of the evaluation with obtaining sufficient information to give such details as are generally required by the average operating refinery.

With the diversity of refining processes now in use, it is impossible to cater in a single analysis for all permutations and combinations of refinery operations. Likewise, since no two refineries require exactly the same straight cuts from crude, some arbitrary choice of cutting points has to be made. In order to cover this point, the distillation methods as specified make provision for a temperature/percentage distillate record to be taken, from which it is possible to produce distillation curves, thus allowing computation of the yield of any desired cut to be made.

As regards the stipulation of the tests to be carried out on the chosen fractions, the Committee consider that the range of tests given cover the main requirements for any purpose to which such cuts can be put.

No method for estimation of wax in the heavy distillate has as yet been included. The Sub-Committee still have this point under consideration, and four possible methods are being studied.

Since an evaluation such as described must eventually be tied in with actual refinery operations, it is considered that the method will have to be used in a comparative rather than in an absolute manner. For instance, a refiner can carry out the specified evaluation method on a crude which he normally runs in the refinery, and of which he has exact estimates of the yields of desired products obtainable. If then he desires to run a different crude on which the results of the proposed evaluation are available, it should be possible for him to make a good estimate of the yields and qualities of the products which he can obtain on this second crude.

Turning to the actual methods which have been evolved for the detailed evaluation, the Committee feel that the apparatus used to evaluate fractions up to 350° C. boiling point at atmospheric pressure are comparable in fractionating efficiency to modern refinery plant, and also that it is sufficiently robust and well designed to meet with general favour. In considering the apparatus to be used for the separation of the heavier fractions of the crude oil, however, the Committee did give serious consideration to the specification of a single flash pipestill method which would reduce the crude to a short residue without the dangers of possible cracking such as occur in batch distillation. Also, it is considered that by the introduction of a continuous distillation method it will be possible to run the crude oil to a shorter residue than the present method will allow. The difficulties of standardizing such an apparatus and technique were such that it was not thought possible to produce a suitable method for publication in the 1944 "Standard Methods," and that, for the time being at least, a batch distillation would have to be specified.

Lastly, the question as to whether chemical and/or physical treatments should be stipulated for the various distillate fractions was considered, but here again it was felt that, as the distillation fractions specified were not chosen to represent any particular product, there could be no point in stipulating the treatments to which such fractions should be subjected.

REPORT OF SUB-COMMITTEE NO. 3—LIQUEFIED PETROLEUM GASES, GASOLINE, KEROSINE, AND LIGHT DISTILLATES.

At the end of 1942 the various Sub-Committees of the Institute of Petroleum Standardization Committee were re-constituted in order to bring and keep up to date the "Standard Methods for Testing Petroleum and its Products" issued by the Institute.

Sub-Committee No. 3 as then appointed consisted of nineteen members, and was charged with the responsibility of revising, and, if necessary, adding to, the standard test methods for Liquefied Petroleum Gases, Gasoline, Kerosine, and Light Distillates.

The present composition of the Sub-Committee and its panels is as follows :—

SUB-COMMITTEE 3.

E. B. Evans (*Chairman*) (Anglo-American Oil Co., Ltd.).
F. S. Aumonier (Government Laboratory).
L. J. Bellamy (Ministry of Supply).
E. R. H. Davies (alternate J. W. Armstrong) (Imperial Chemical Industries, Ltd.).
A. E. Dunstan (Anglo-Iranian Oil Co., Ltd.).

F. H. Garner (University of Birmingham).
T. K. Hanson (alternate R. Sefton) (Trinidad Leaseholds, Ltd.).
S. R. Hills (Asiatic Petroleum Co., Ltd.).
W. H. Hoffert (National Benzole Co., Ltd.).
C. D. Lawrence (alternate E. N. Dodd) (Admiralty).
J. Mason (Ministry of Aircraft Production).
G. R. Nixon (Burmah Oil Co., Ltd.).
A. Osborn (Esso European Laboratories).
D. S. Paul (War Office).
A. R. Stark (Anglo-Iranian Oil Co., Ltd.).
T. M. Taylor (Shell Refining and Marketing Co., Ltd.).
W. H. Thomas (Anglo-Iranian Oil Co., Ltd.).
S. A. W. Thompson (alternate J. M. A. Court) (Ministry of Aircraft Production).
W. A. Woodrow (Anglo-American Oil Co., Ltd.).

Burning Test Panel.

S. R. Hills (*Chairman*) (Asiatic Petroleum Co., Ltd.)
D. J. Lewis (Anglo-Iranian Oil Co., Ltd.).
G. R. Nixon (Burmah Oil Co., Ltd.).
A. Osborn (Esso European Laboratories).
D. S. Paul (War Office).
W. A. Woodrow (Anglo-American Oil Co., Ltd.).

Colour Panel.

W. A. Woodrow (*Chairman*) (Anglo-American Oil Co., Ltd.).
E. R. H. Davies (alternate J. W. Armstrong) (Imperial Chemical Industries, Ltd.).
E. N. Dodd (Admiralty).
G. S. Fawcett (The Tintometer, Ltd.).
S. R. Hills (Asiatic Petroleum Co., Ltd.).
W. H. Hoffert (National Benzole Co., Ltd.).
A. R. Javes (Anglo-Iranian Oil Co., Ltd.).
G. R. Nixon (Burmah Oil Co., Ltd.).
A. Osborn (Esso European Laboratories).
R. Sefton (Trinidad Leaseholds, Ltd.).
W. H. Thomas (Anglo-Iranian Oil Co., Ltd.).

Gum Stability Panel.

W. H. Hoffert (*Chairman*) (Anglo-Iranian Oil Co., Ltd.).
E. R. H. Davies (Imperial Chemical Industries, Ltd.).
S. R. Hills (Asiatic Petroleum Co., Ltd.).
J. Mason (Ministry of Aircraft Production).
G. R. Nixon (Burmah Oil Co., Ltd.).
A. Osborn (Esso European Laboratories).
R. Sefton (Trinidad Leaseholds, Ltd.).
T. M. Taylor (Shell Refining and Marketing Co., Ltd.).
W. H. Thomas (Anglo-Iranian Oil Co., Ltd.).
W. A. Woodrow (Anglo-American Oil Co., Ltd.).

Sulphur Panel.

W. H. Thomas (*Chairman*) (Anglo-Iranian Oil Co., Ltd.).
J. W. Armstrong (Imperial Chemical Industries, Ltd.).
G. Claxton (National Benzole Co., Ltd.).
A. R. Javes (Anglo-Iranian Oil Co., Ltd.).
R. Sefton (Trinidad Leaseholds, Ltd.).
T. M. Taylor (Shell Refining and Marketing Co., Ltd.).
W. A. Woodrow (Anglo-American Oil Co., Ltd.).

Liquefied Gases Panel.

W. H. Thomas (*Chairman*) (Anglo-Iranian Oil Co., Ltd.).
J. W. Armstrong (Imperial Chemical Industries, Ltd.).
N. Aston (Agwi Petroleum Corporation, Ltd.).
J. H. D. Hooper (Anglo-Iranian Oil Co., Ltd.).
N. E. Jones (Trimpell, Ltd.).

From January to July 1943 Sub-Committee No. 3 has met on five occasions. A number of test methods have been dealt with by the full

Sub-Committee, but it has been found convenient to appoint a number of Panels to consider certain tests. This has been the case either when a considerable amount of experimental work has been necessary, or when the tests have been of a very specialized character. The work of the various Panels has been greatly helped by the co-option of ten additional members having specialized knowledge of the subjects under discussion.

The Panels, five in number, and the subjects with which they are concerned are as follows :—

Burning Test Panel.

The present methods for evaluation of the burning properties of kerosines were revised in 1940. It has been felt, however, that some improvement could be made in the method of char estimation, and considerable work has been carried out on this subject. This work is still in progress, and no change can be recommended for the moment, but it is hoped that a better method than the present hand-scraping procedure for char removal will be available before very long.

Colour Panel.

This Panel is concerned with the measurement of colour, chiefly of the light petroleum products. The two methods now standardized, using the Lovibond Tintometer and the Saybolt Chromometer, have been examined, in co-operative work by a number of laboratories, for reproducibility of results. A correlation between the results of measurements by the two instruments has been worked out. This provides a conversion between I.P.-Lovibond numbers and Saybolt colour shades. Such a conversion can, of course, be only approximate and appreciable divergencies from the curve may sometimes occur, particularly with the darker-coloured products. This is a consequence of the methods involving comparison of the colours of products with those of arbitrary colour glasses, which cannot in all cases match precisely the tint of the sample being examined. It is felt, however, that a curve of this type should be useful for general purposes, and details have been published in the *Journal* of the Institute (*J. Inst. Petrol.*, Dec. 1943, **29** (240), 353).

Another problem which is engaging the attention of the Colour Panel is that of colour measurement in terms of International (I.C.I. or C.I.E.) Units.

Gum Stability Panel.

The estimation of gum and similar residues in motor fuels, kerosines, tractor fuels, etc., has been the subject of a great deal of work, and a large number of methods are in use in different countries, both for the estimation of existent gum, and also for measuring the stability of motor fuels to storage and oxidising conditions.

Some modifications to " Standard Methods " have been proposed. The glass flask for Gum (Potential) in Motor Fuel (I.P. 39/42 (T)) appears no longer to be used, and will disappear from future editions of " Standard Methods." Some form of bomb-oxidation method is generally favoured for potential gum estimation, and also as a means of determining the stability of leaded fuels. Method I.P. 40/42 (T) was identical with the

current A.S.T.M. Method (D.525–42T) for oxidation stability. It has been found, however, that some difficulty arises with the interpretation of the "break-point" as specified by the A.S.T.M. All fuels do not show the required rate of pressure drop. It is accordingly proposed to specify the break-point as "that point at which the pressure has fallen exactly 2-lbs./sq. in. below its maximum steady value." For most fuels the result would agree with the result by the A.S.T.M. method within experimental error; and, moreover, the definition is capable of application to all fuels which show a susceptibility to oxidation.

A.S.T.M. Method D.381–42 describes the estimation of gum in gasoline by evaporation in a current of hot air. This very useful method, with slight modification, can be applied to the estimation of gum and other residues in kerosines and tractor fuels. A slightly modified method of this type is being proposed for inclusion in "Standard Methods."

Sulphur Panel.

Among the tests considered by this Panel, are the well-known Doctor Test, the estimation of mercaptans, the estimation of corrosion by sulphur compounds, and the estimation of total sulphur in all classes of product from liquefied gases to kerosines.

The Panel is one of those most recently formed by Sub-Committee No. 3, but it has already given consideration to a number of problems, and, it is hoped, will shortly be in a position to make definite recommendations.

The qualitative description of copper strips in the usual corrosion tests, and the correlation of the appearance of the strips with the corrosive properties of fuels have always been a matter of some difficulty, and the Panel is investigating a proposed method to overcome the difficulty. Another subject under examination is the quantitative estimation of mercaptans by an electrometric titration method. A description of the method proposed has been published by two members of the Sub-Committee in *J. Inst. Petrol.*, Nov. 1943, **29** (239), 323.

Moderate amounts of sulphur compounds in unleaded motor fuels are of no great importance. In aviation fuels and leaded fuels, however, even very small amounts of sulphur may be very harmful and it is in consequence necessary to have means of estimating with accuracy these low proportions of sulphur (0·01% and less) as well as the larger amounts (0·1% or so). This problem also is receiving attention.

Liquefied Gases Panel.

The Standardization Committee has not previously concerned itself with the analysis of hydrocarbon gases and liquefied gases. The subject is of obvious importance in refinery control, and also in connection with the marketing of liquefied gases, such as propane and butane for domestic and industrial purposes.

A recently formed Panel of Sub-Committee No. 3 is concerned with analytical methods of this kind. Considerable progress has already been made in the examination of available methods, and it is hoped that before long "Standard Methods" may contain details of recommended methods for this type of work.

Other Methods Considered By Sub-Committee.

A number of other methods have also been considered by the Sub-Committee, and minor revisions or extensions made to some of the existing methods—*e.g.*, Aniline Point (I.P. 2/42), Aromatic Content (I.P. 3/42), Cold Test (I.P. 16/42), Flash Point by Abel Method (I.P. 33/42).

The method for Vapour Pressure (I.P. 69/42) has been further modified to make it suitable for use with motor fuels containing alcohol or other water-soluble constituents which would separate with the amount of water left in the bomb after purging by the usual procedure.

A method for Water Tolerance of Motor Fuels containing water-soluble constituents, such as alcohols or ketones, has been standardized. Methods for this determination have been in use for a number of years, and it was felt that a recommended procedure should be included in "Standard Methods."

A related problem is that of the tendency of fuel filters to choke at low temperatures, due to separation of ice particles from aviation fuels which have a slight solubility for water at normal temperatures. A method for evaluating this tendency has been discussed and a paper by a member of the Sub-Committee describing the method has been published in the *J. Inst. Petrol.*, Nov. 1943, **29** (239), 329.

The foregoing notes are intended to give a brief summary of the work carried out by Sub-Committee No. 3 since January 1943, together with an indication of the lines on which further work is proceeding. The whole range of tests on the products concerned will be kept constantly under review, and from time to time tests of wide application, after careful examination in detail, will be recommended for inclusion in "Standard Methods."

REPORT OF SUB-COMMITTEE NO. 4—GAS, DIESEL AND FUEL OIL.

The personnel of Sub-Committee No. 4 and its three panels are as follows :—

Sub-Committee 4.

A. R. Stark (*Chairman*) (Anglo-Iranian Oil Co., Ltd.).
W. E. J. Broom (Esso European Laboratories).
G. H. Brown (Admiralty).
J. S. Jackson (Asiatic Petroleum Co., Ltd.).
F. H. Jones (War Office).
C. D. Lawrence (Admiralty).
J. Parrish (Shell Refining and Marketing Co., Ltd.).
S. R. Pethrick (Royal Aircraft Establishment).
G. H. Smith (Scottish Oils, Ltd.).
W. H. Thomas (Anglo-Iranian Oil Co., Ltd.).
A. T. Wilford (London Passenger Transport Board).
W. Woodrow (Anglo-American Oil Co., Ltd.).

Diesel Index-Cetane Number Correlation Panel.

J. Parrish (*Chairman*) (Shell Refining and Marketing Co., Ltd.).
W. E. J. Broom (Esso European Laboratories).
G. H. Smith (Scottish Oils, Ltd.).
W. H. Thomas (Anglo-Iranian Oil Co., Ltd.).
A. T. Wilford (London Passenger Transport Board).

Asphaltenes in Crude Oil Panel.

J. Parrish (*Chairman*) (Shell Refining and Marketing Co., Ltd.).
B. C. Allibone (Burmah Oil Co., Ltd.).
L. O. Maskell (Silvertown Lubricants, Ltd.).
W. H. Thomas (Anglo-Iranian Oil Co., Ltd.).
W. Woodrow (Anglo-American Oil Co., Ltd.).

Stability of Fuel Oils Panel.

W. E. J. Broom (*Chairman*) (Esso European Laboratories).
J. Parrish (Shell Refining and Marketing Co., Ltd.).
R. G. Sefton (Trinidad Leaseholds, Ltd.).
G. H. Smith (Scottish Oils, Ltd.).
W. H. Thomas (Anglo-Iranian Oil Co., Ltd.).
A. T. Wilford (London Passenger Transport Board).

Only one new test, "The Low Temperature Filtration Test of Gas Oils, etc.", I.P. 85/44, has been proposed for the 1944 edition of "Standard Methods."

Diesel Index-Cetane Number Correlation Panel.

The wording of the introduction of Diesel Index I.P. 21/42 was considered to be unsatisfactory and the Sub-Committee felt that much more than a mere clarification of the scope of the test was required, since, to be really useful, the diesel index should be directly correlatable with actual determined cetane number. On the samples of marketed high-speed diesel fuels examined it was found that the I.P. diesel index in extreme cases differed from the determined cetane number by as much as 9 cetane numbers.

A survey was therefore made of the existing methods for determination of ignition quality of diesel fuels, but no recommendation could be made of an alternative method, since the correlation with cetane number was in no case completely satisfactory. The panel was therefore reluctantly compelled to limit itself, as far as the 1944 Edition of "Standard Methods" was concerned, to making an alteration to the text of the existing method, pointing out that direct correlation between diesel index and cetane number is not to be expected. Work on this subject has not, however, been completely dropped, but is continuing. Should it be found that a correlation such as the above is not possible, then the Committee will publish the results of their investigation in full in the *Journal*.

Asphaltenes in Crude Oil Panel.

It was pointed out by Sub-Committee No. 2 that there were certain waxy and asphaltic crude residues, in which the asphaltenes as determined by the existing method I.P. 6/42 were much in excess of the true value, due to the fact that high-melting-point waxes remained included with the precipitated asphaltenes. A case was reported in which approximately 90 per cent. of the precipitate was wax of setting point 195° F., which was only very slightly soluble in ethyl alcohol.

A panel was therefore appointed to consider this point, the approach to a solution being sought in the first place by the use of solvents alternative to ethyl alcohol, retaining the other conditions of the test exactly as laid down. The following solvents were tried: amyl alcohol, butyl alcohol,

*iso*propyl alcohol, *cyclo*hexanol, butanone, methyl ethyl ketone, *cyclo*hexanone, and I.P. spirit. In all cases washing was to be carried out by the refluxing procedure.

Correlation of results between the three participating laboratories was not satisfactory, and there was surprisingly little difference in the order of results obtained by the various solvents. It was felt that since the results obtained by each laboratory were self-consistent, there was a possibility that standardization would have to be taken back a farther step to include the I.P. precipitation spirit.

As regards the small differences obtained between the wax solvents, there is always the possibility that these differences are by no means straightforward, since in some cases asphaltenes may be dissolved out along with the waxes present. In order to elucidate this point, an examination is now to be made of the materials which have been dissolved out by the solvents.

It is anticipated that several months' work lies in front of this panel before a solution to the problem will be obtained.

Stability of Fuel Oils Panel.

When No. 4 Sub-Committee was reconstituted, the Main Standardization Committee requested that work should be undertaken to evolve a method of determination of stability of furnace oils.

After consideration, the Sub-Committee came to the conclusion that this problem could most properly be considered as consisting of three parts :

(*a*) Stability during storage.

(*b*) Dilution stability such as would occur on blending either two furnace oils or cutting back a furnace oil with a distillate oil.

(*c*) Stability to preheat treatment immediately before use.

The three methods of test which had found most general acceptance among those available to the Sub-Committee were chosen for investigation.

In case (*a*) tests which used a dilution method were ruled out completely because of the possibility of either precipitation or resolution of constituents of the material under investigation. Storage at a temperature of 100° F. was chosen in the first case, and precipitated material was measured by the " Hot Filtration Test," which consists of filtering the undiluted sample from the storage test through a steam jacketed filter funnel of the Gooch type under a pressure of approximately 10 inches of mercury. This work is proceeding satisfactorily.

In case (*b*) the method chosen is a modification of the Oliensis spot test, in which the sample under examination is agitated with mixtures of xylene and a paraffinic solvent, the percentage of xylene being progressively increased until the sample shows no nuclear ring on being spotted on filter paper.

Up to the present this method has not been quite satisfactorily worked out, and minor modifications to procedure are under investigation. The indications at present are that the basic method is sound enough to warrant further investigation.

In case (*c*) the method chosen was the Heater Test evolved by the American Naval Boiler and Turbine Laboratory, which consists in circulating the sample, heated to a temperature equivalent to a specified viscosity and observing the quantity and nature of the deposit formed on the heater tube. This test has been shown to give consistent and repeatable results but the Sub-Committee feels that it cannot recommend its adoption at present, since the classification adopted by the U.S. authorities is unduly restrictive for normal commercial usage. An attempt will be made to evolve a new and more generally acceptable classification based on commercial experience.

It is interesting to note in this connection that on blending two fuels of equal degree of stability as measured by this test a less stable fuel may result. This finding is in agreement with practical experience in some cases.

The Sub-Committee has felt itself so limited in opportunity to perform experimental work due to prevailing conditions that it decided not to embark on further projects until those mentioned above were drawing to a conclusion. It has in mind, however, that there are necessities for several new tests and improvements to existing ones. Among the former the Committee has in mind, when time permits, work on the emulsifying tendencies of marine furnace oils, and the determinations of aniline and cloud points of oils which are too opaque to permit of the present standard methods to be used.

REPORT OF SUB-COMMITTEE NO. 5—ENGINE TESTS.

The personnel of this Sub-Committee and of its panels is as follows :—

SUB-COMMITTEE 5.

F. H. Garner (*Chairman*) (University of Birmingham).
C. H. Barton (Asiatic Petroleum Co., Ltd.).
E. L. Bass (Ministry of Aircraft Production).
E. A. Evans (C. C. Wakefield & Co., Ltd.).
E. B. Evans (Anglo-American Oil Co., Ltd.).
E. Giffen (Institution of Automobile Engineers).
L. J. le Mesurier (Admiralty).
J. A. Oriel (Asiatic Petroleum Co., Ltd.).
D. S. Paul (War Office).
K. E. W. Ridler (Ministry of Aircraft Production).
R. Stansfield (Anglo-Iranian Oil Co., Ltd.).
A. T. Wilford (London Passenger Transport Board).
C. G. Williams (Thornton Aero Engine Research Laboratories).
C. S. Windebank (Anglo-American Oil Co., Ltd.).
J. G. Withers (Anglo-Iranian Oil Co., Ltd.).

Knock Rating of Aviation Fuel Panel.

K. E. W. Ridler (*Chairman*) (Ministry of Aircraft Production).
E. R. H. Davies (Imperial Chemical Industries, Ltd.).
P. Draper (Asiatic Petroleum Co., Ltd.).
T. K. Hanson (Trinidad Leaseholds, Ltd.).
J. Mason (Ministry of Aircraft Production).
C. H. Sprake (Esso European Laboratories).
R. Stansfield (Anglo-Iranian Oil Co., Ltd.).
S. A. W. Thompson (Royal Aircraft Establishment).
C. G. Williams (Thornton Aero Engine Research Laboratory).

Knock Rating of Motor Fuel Panel.

R. Stansfield (*Chairman*) (Anglo-Iranian Oil Co., Ltd.).
B. C. Allibone (Burmah Oil Co., Ltd.).
N. L. Anfilogoff (Texas Oil Co., Ltd.).
L. W. Barnard (National Benzole Co., Ltd.).
C. H. Barton (Asiatic Petroleum Co., Ltd.).
P. Draper (Asiatic Petroleum Co., Ltd.).
H. Fossett (British Ethyl Corporation).
E. Giffen (Institution of Automobile Engineers).
T. K. Hanson (Trinidad Leaseholds, Ltd.).
J. H. Pitchford (Ricardo & Co., Ltd.).
C. Sprake (Esso European Laboratories).

Ignition Quality of Diesel Fuel.

R. Stansfield (*Chairman*) (Anglo-Iranian Oil Co., Ltd.).
K. T. Arter (Esso European Laboratories).
S. J. Davies (King's College. London).
C. B. Dickson (British Standards Institution).
P. Draper (Asiatic Petroleum Co., Ltd.).
E. Giffen (Institution of Automobile Engineers).
L. J. le Mesurier (Admiralty).
D. S. Paul (War Office).
A. T. Wilford (London Passenger Transport Board).
J. G. Withers (Anglo-Iranian Oil Co., Ltd.).

Mechanical Tests of Lubricants Panel.

C. G. Williams (*Chairman*) (Thornton Aero Engine Research Laboratory).
K. T. Arter (Esso European Laboratories).
C. H. Barton (Asiatic Petroleum Co., Ltd.).
D. Clayton (Ministry of Supply).
E. A. Evans (C. C. Wakefield & Co., Ltd.).
E. Giffen (Institution of Automobile Engineers).
L. J. le Mesurier (Admiralty).
A. R. Ogston (International Aviation Association).
D. S. Paul (War Office).
J. H. Pitchford (Ricardo & Co., Ltd.).
V. H. Rumble (Anglo-Iranian Oil Co., Ltd.)
G. H. Simmons (C. C. Wakefield & Co., Ltd.).
R. Stansfield (Anglo-Iranian Oil Co., Ltd.).
S. A. W. Thompson (Royal Aircraft Establishment).
H. L. West (Esso European Laboratories).
A. T. Wilford (London Passenger Transport Board).

Aviation Fuel Panel.

The Aviation Fuel Panel is maintaining a close collaboration with the work being done in the U.S.A. on various methods of rating aviation fuels.

A note has been published in the *Journal* referring to the calibration of C.F.R. reference fuels F.4 and C.12 with the addition of 4 mls. T.E.L. per Imperial Gallon, both by the motor method and the 17° motor method.

Motor Fuel Panel.

The Motor Fuel Panel has not been very active during the past year, but has made a slight modification in the method of test I.P. 44/42 (T). This modification involves the removal of the throttle plate in the carburetter of the C.F.R. engine in order to bring the I.P. method into line with the A.S.T.M. (D-2) method. A similar modification has been accepted by the Aviation Fuel Panel for method I.P. 42/42 (T).

Ignition Quality of Diesel Fuel Panel.

The Ignition Quality of Diesel Fuel Panel has investigated the relation between cetane numbers of a number of diesel fuels, both by the I.P. method 41/42 (T) and the corresponding A.S.T.M. method D.613/41T, which uses the C.F.R. Diesel Fuel Testing Unit. It was found that the correlation was satisfactory, bearing in mind the reproducibility specified in the I.P. method. A modification of the wording has been made in I.P. 41/42 (T) to call attention to this agreement in ratings by the two methods.

Mechanical Tests of Lubricants Panel.

The various methods of test for special E.P. lubricants have been discussed, including the use of the S.A.E. machine, the Four Ball machine, the Cornell machine with the modified method of test used by the Ford Motor Company, and the Almen method. A report has been prepared by Mr. H. L. West on the testing of E.P. lubricants which will be presented at a meeting of the Institute early in 1944, and it is felt that the discussion of this paper should be helpful as an indication of the necessity for such tests and of the type of tests desirable.

The A.S.T.M. adopted the 35-hour Chevrolet test as a proposed method of test for oxidation characteristics of heavy-duty crankcase oil in 1942, and the Panel has considered both this and other tests on the Caterpillar engines, in view of the adoption of such engine test methods in the specification for crankcase oils used in the Services. Mr. C. H. Barton is preparing a paper on these methods of test which will be presented at a meeting of the Institute.

Tests on Turbine oil, such as the U.S. Navy work factor test, have also been discussed in view of their use in some specifications. No decision has, however, yet been reached by the Panel on the adoption of additional methods of test to those included in " Standard Methods " of Test for 1942.

REPORT OF SUB-COMMITTEE NO. 6—LUBRICANTS.

The Sub-Committee obtained the assistance of four panels which were styled the Miscellaneous Tests Panel, the Oxidation Panel, the Viscosity Panel and the Grease Panel.

The members of the Sub-Committee and Panels are as follows :—

Sub-Committee 6.

E. A. Evans (*Chairman*) (C. C. Wakefield & Co., Ltd.).
N. L. Anfilogoff (Texas Oil Co., Ltd.).
S. C. Atkinson (Ministry of Supply).
S. J. M. Auld (Vacuum Oil Co., Ltd.).
C. H. Barton (Asiatic Petroleum Co., Ltd.).
W. E. J. Broom (Esso European Laboratories).
D. Clayton (Ministry of Supply).
C. D. Lawrence (Admiralty).
L. O. Maskell (Silvertown Lubricants, Ltd.).
J. Mason (Ministry of Aircraft Production).
D. S. Paul (alternate H. F. Jones) (War Office).
E. R. Pethrick (Royal Aircraft Establishment).
E. R. Redgrove (Snowdon, Sons & Co., Ltd.).

K. E. W. Ridler (Ministry of Aircraft Production).
A. R. Stark (Anglo-Iranian Oil Co., Ltd.).
R. D. Streeton (Anglo-American Oil Co., Ltd.).
J. L. Taylor (Petroleum Board).
W. H. Thomas (Anglo-Iranian Oil Co., Ltd.).

Grease Panel.

E. A. Evans (*Chairman*) (C. C. Wakefield & Co., Ltd.).
S. C. Atkinson (Ministry of Supply).
J. A. Bell (Shell Refining and Marketing Co., Ltd.).
H. W. Chetwin (Chetwin, Newark & Co., Ltd.).
D. Clayton (alternate Dr. M. Thompson) (Ministry of Supply).
E. G. Ellis (Vacuum Oil Co., Ltd.).
F. J. S. Hall (Horton Manufacturing Co., Ltd.).
J. Hill (London and North Eastern Railway).
C. D. Lawrence (Admiralty).
L. O. Maskell (Silvertown Lubricants).
W. Pethrick (Royal Aircraft Establishment).
M. W. Webber (Hill and Jackson, Ltd.).
H. L. West (Esso European Laboratories).

Grease Panel Working Group.

H. W. Chetwin (*Chairman*) (Chetwin, Newark & Co., Ltd.).
S. C. Atkinson (alternates L. J. Bellamy and H. Hollis) (Ministry of Supply).
J. A. Bell (Shell Refining and Marketing Co., Ltd.).
E. G. Ellis (Vacuum Oil Co., Ltd.).
F. J. S. Hall (Horton Manufacturing Co., Ltd.).
G. H. J. Simmons (C. C. Wakefield & Co., Ltd.).
H. L. West (Esso European Laboratories).

Viscosity Panel.

G. Barr (*Chairman*) (National Physical Laboratory).
N. L. Anfilogoff (Texas Oil Co., Ltd.).
W. E. J. Broom (Esso European Laboratories).
J. Cantor (Shell Refining and Marketing Co., Ltd.).
J. C. Cragg (C. C. Wakefield & Co., Ltd.).
E. B. Evans (Anglo-American Oil Co., Ltd.).
F. H. Garner (University of Birmingham).
J. L. Taylor (Petroleum Board).

Viscosity of Working Group.

G. Barr (*Chairman*) (National Physical Laboratory).
J. C. Cragg (C. C. Wakefield & Co., Ltd.).
E. G. Ellis (Vacuum Oil Co., Ltd.).
J. H. Joyce (Ministry of Aircraft Production).
M. M. Lapitzky (Shell Refining and Marketing Co., Ltd.).
A. H. Nissan (University of Birmingham).
L. Steiner.
R. D. Streeton (Anglo-American Oil Co., Ltd.).
H. L. West (Esso European Laboratories).

Oxidation Panel.

R. D. Streeton (*Chairman*) (Anglo-American Oil Co., Ltd.).
S. C. Atkinson (alternate H. Hollis) (Ministry of Supply).
D. Clayton (alternate Dr. M. Thompson and G. Kimmer) (Ministry of Supply).
E. G. Ellis (Vacuum Oil Co., Ltd.).
N. F. Hitchcock (C. C. Wakefield & Co., Ltd.).
D. M. Japes (Shell Refining & Marketing Co., Ltd.).
L. O. Maskell (Silvertown Lubricants, Ltd.).
J. Mason (alternate J. H. Joyce) (Ministry of Aircraft Production).
H. L. West (Esso European Laboratories).

Miscellaneous Tests Panel.

L. O. Maskell (*Chairman*) (Silvertown Lubricants).
N. L. Anfilogoff (Texas Oil Co., Ltd.).
S. C. Atkinson (alternate F. Bellamy) (Ministry of Supply).
J. C. Cragg (C. C. Wakefield & Co., Ltd.).

R. W. Dawe (co-opted) (Great Western Railway).
E. G. Ellis (Vacuum Oil Co., Ltd.).
C. D. Lawrence (alternates E. N. Dodd and D. Wyllie) (Admiralty).
J. Mason (alternate J. H. Joyce) (Ministry of Aircraft Production).
D. S. Paul (alternate H. F. Jones) (War Office).
W. Pohl (Shell Refining and Marketing Co., Ltd.).
R. D. Streeton (Anglo-American Oil Co., Ltd.).
J. L. Taylor (Petroleum Board).
W. H. Thomas (Anglo-Iranian Oil Co., Ltd.).
A. T. Wilford (London Passenger Transport Board).

The Miscellaneous Tests Panel was not able to give detailed consideration to all the matters which came within its terms of reference. Therefore, some tests have been re-adopted without reconsideration. The Viscosity Panel has been faced with the greatest difficulty, and until its Working Group has proceeded further with its present investigation it is not possible to give a carefully considered opinion upon the precision requirements introduced in the 1942 edition under the heading of "Kinematic Viscosity." The Grease Panel has considered greases which may simultaneously be both acid and alkaline. It is now giving consideration to stability.

Grease Panel.

The Grease Panel has given attention to the outstanding difficulty occasioned by the simultaneous presence of free alkali and free acid in grease. A definite procedure has now been introduced for the first time to meet this difficulty. The Panel has adopted B.S.I. Drop Point Apparatus, and, to meet the special demands of the Petroleum Industry, has recommended the use of a metal cup instead of glass. The glass cups are very difficult to make to the dimensions which are felt to be necessary.

A working group has been formed for this panel.

Viscosity Panel.

The Viscosity Panel has been faced with a great difficulty. It wishes to keep a parallel course with the A.S.T.M., but it realizes that the anticipated precision given in the 1942 edition will be very difficult to attain during the War period. It has therefore come to the conclusion that as the word "accuracy" is defined in Standard Methods, 0·3 per cent. means a departure of $\pm 0{\cdot}3$ per cent. from the true value.

In the 1944 edition, a tolerance of $\pm 0{\cdot}3$ per cent. will be allowed for the finished calibrated viscometer and a further $\pm 0{\cdot}3$ per cent. tolerance permitted for the actual laboratory measurement on a sample of oil. This means a possible departure of $\pm 0{\cdot}6$ per cent. from the *true value*. The object for this degree of accuracy is to meet the growing demand for a more accurate expression of viscosity index. When viscosity index is demanded, a much closer attention must be given to the measurement of viscosity. The Viscosity Panel has appointed a Working Group to investigate certain details which are, at the moment, somewhat obscure. The Panel has abandoned the use of 40 per cent. sucrose solution as a primary standard. For the time being it is intended to retain water and 60 per cent. sucrose solution as primary standards, but it realizes that the subject of primary standards needs careful consideration. In view of the present limitations, the only capillary viscometers which shall be permitted are the Suspended Level, Fenske and B.S.I.

Oxidation Panel.

The Oxidation Panel has reviewed the existing oxidation tests, and has given consideration to numerous other oxidation tests, including those detailed by the A.S.T.M.

The Sub-Committee is very grateful to its corresponding Committee of the A.S.T.M. whose co-operation augers well for the future.

The Oxidation Panel has made several adjustments in the tests which it has reviewed. Probably they will be considered to be minor adjustments. It is not unmindful of the difficulty of removing the solid from the flask in the Sludging Test, but before making any proposal it is seeking the co-operation of B.E.I.R.A. The necessary adjustment has been made in the dimensions of the apparatus used in the Ramsbottom Carbon Residue Test.

Miscellaneous Tests Panel.

The Miscellaneous Tests Panel has given careful attention to Alkali Blue for use as the indicator for acidity estimation. By sensitizing this indicator it can be made to yield extremely satisfactory results and has a wider application than phenolphthalein.

Clearly it would not be good policy to abandon phenolphthalein after so many years of standardized service until there has been sufficient time for more experience with sensitized Alkali Blue. The Panel has realized that the expression "Preliminary Transient Sparking" in the di-electric strength test gives rise to some ambiguity. Consequently communication has been made with B.E.I.R.A., and it is now hoped that a satisfactory conclusion has been reached. Now that the A.S.T.M. has included the Ramsbottom Carbon Residue Test in its Standard Methods, the Panel feels that the Conradson Carbon Residue Test should be abandoned for Lubricating Oils. In fact, it recommends that the Ramsbottom Method should receive preferential consideration whenever a Carbon Residue Test is required.

Both the Miscellaneous Tests Panel and the Oxidation Panel have found it necessary to place safeguards on all tests which might be affected by the presence of chemical additions. This is a very necessary step to take now that chemical additives are being used on a commercial scale.

REPORT OF SUB-COMMITTEE NO. 7—ASPHALTIC BITUMEN.

The following Sub-Committee and Panels have been set up to deal with asphaltic bitumen methods :—

Sub-Committee 7.

J. S. Jackson (*Chairman*) (Asiatic Petroleum Co., Ltd.).
D. C. Broome (Limmer and Trinidad Lake Asphalt Co., Ltd.).
I. Cameron (British Bitumen Emulsions, Ltd.).
L. G. Gabriel (Colas Products, Ltd.).
C. F. Jackson (Shell Refining and Marketing Co., Ltd.).
A. W. Jarman (Petroleum Board).
H. S. Keep (alternate H. F. Gillbe) (Ministry of War Transport).
A. R. Lee (Road Research Laboratory).
A. Osborn (Esso European Laboratories).
P. E. Spielman.

A. R. Stark (Anglo-Iranian Oil Co., Ltd.).
W. H. Thomas (Anglo-Iranian Oil Co., Ltd.).
E. Vannan (Neuchatel Asphalte Co., Ltd.).
D. M. Wilson (D. Anderson & Son, Ltd.).
D. A. Yonge (Shell Refining and Marketing Co., Ltd.).

Bituminous Emulsions Panel.

I. Cameron (*Chairman*) (British Bitumen Emulsions, Ltd.).
L. G. Gabriel (Colas Products, Ltd.).
H. Gardner (Shell Refining and Marketing Co., Ltd.).
A. R. Lee (Road Research Laboratory).
A. Osborn (Esso European Laboratories).
W. H. Thomas (Anglo-Iranian Oil Co., Ltd.).
D. M. Wilson (D. Anderson & Sons, Ltd.).

Soil Stabilization Panel.

L. G. Gabriel (*Chairman*) (Colas Products, Ltd.).
J. F. T. Blott (Shell Refining and Marketing Co., Ltd.).
I. Cameron (alternate A. E. Lawrence) (British Bitumen Emulsions, Ltd.).
R. Glossop (John Mowlem & Co., Ltd.).
H. S. Keep (alternate H. F. Gillbe) (Ministry of War Transport).
A. D. H. Markwick (alternates K. E. Clare and L. Maddison) (Road Research Laboratory).
A. Osborn (Esso European Laboratories).
R. K. Schofield (Agricultural Research Station, Rothamsted).
A. R. Stark (Anglo-Iranian Oil Co., Ltd.).

Apart from the normal consideration of existing methods, and the adoption of new asphaltic bitumen methods, two important decisions were taken by the main Standardization Committee. In the first place, it was decided that the next edition of "Standard Methods" should include descriptions of as many as possible of the methods available for the testing of bituminous emulsions. Secondly it was decided that this Committee should undertake a survey of the various methods already in use in connection with soil stabilization processes involving the use of petroleum products.

Bituminous Emulsions Panel.

This panel has already made good progress and the following emulsion methods will appear in the next edition of "Standard Methods":—

1. Water Content.
2. Residue on sieving.
3. Coagulation of Binder.
4. Stability in Bulk.

The Engler viscometer has also been adopted as the standard instrument for the determination of the viscosity of emulsions, but time will not permit of the preparation of a full description of this method for publication in the next edition. The whole of the above methods are broadly based on the existing methods published in B.S.S.434.

The panel will continue the consideration of the following methods which all call for further discussion or investigation:—

1. Coagulation at low temperature.
2. Lability Demulsification and Cement Testing.
3. Sedimentation.
4. Proportion of emulsifying agent.

5. Alkalinity.
6. Miscibility with water.
7. Freezing Test.
8. Particle size.

The B.S.–A.R.P. tests will also be considered with a view to selecting those of permanent value.

Soil Stabilization Panel.

Much good work has already been accomplished by this Panel. In the first place, existing schedules of test were reviewed and the corresponding tests set down for discussion, with the object of eliminating minor variations in operation where these exist. In this way it is hoped to arrive at standardized versions which can be used for future work on this very complex problem of soil stabilization, thus providing the maximum interchangeability of data between the various laboratories working in this field. The schedules of test considered included the following :—

1. Tests sponsored in almost identical form by the American Society for Testing Materials and the American Society of State Highway Officials.
2. Tests recommended by the International Society for Soil Science.
3. Tests which appeared in the general discussion at the Hague Road Congress in 1938.
4. Tests in use in the following laboratories :—
   a. Road Research, Harmondsworth.
   b. British Bitumen Emulsions, Ltd.
   c. Shell Refining and Marketing Co., Ltd.

The tests chosen for the first discussions were those on the performance of a stabilized mix. These have now been considered in detail, and in the near future it is hoped that they will be satisfactorily co-ordinated, and consideration will then be given to the ancillary tests necessary to classify the soils and other materials used in the processes under review.

In the discussions which have taken place it has become apparent that a simple smoothing out of detail variations between tests will not be possible, and certain tests which do not fit in completely with the scheme will have to be included because of their general interest. It is therefore considered necessary that the schedules of test which will ultimately be put forward by the panel shall be accompanied by a fairly extensive explanatory report setting out the reasons for the course taken in arranging the tests. It is thought that this explanatory report will be of great value in summarizing the position of soil stabilization from the aspect of the measurement of results obtained. In view of this fact, it is not deemed advisable to submit the tests already considered for inclusion in the next edition of "Standard Methods." The report of this panel will be published as a separate pamphlet giving a survey of soil stabilization methods. It is hoped in this way to ensure a wider discussion of these methods, and further experience of their use before actual standardization is attempted.

The British Standards Institution has also set up a committee to study the general question of soil stabilization. Contact has already been made

with this committee and the closest co-operation can be confidently anticipated.

Descriptions of the following tests have already been prepared :—

1. The cone penetration resistance of a compacted stabilized soil.
2. Capillary water absorption test.
3. Compression test.
4. Rapid water absorption test by immersion.

As regards the normal work of the main sub-Committee, only two major changes have been recommended. The Fraass Breaking Point Test has been described, and will be included in the next edition. I.P. Method 8/42 Asphaltene (soft asphalt) is no longer in common use, and will therefore be withdrawn. The minor alterations to other standardization methods to bring them up-to-date will be dealt with in detail in " Standard Methods." As regards the future work of the Sub-Committee, a sulphonation test for the examination of tar bitumen mixtures is under investigation by a group of laboratories, which have already reported promising results. The possibility of evolving a satisfactory method for estimating the paraffin-wax content of asphaltic bitumen is also under consideration. The desirability of describing a method for the recovery of asphaltic bitumen from coated aggregates, etc., will also be considered.

The Sub-Committee will, at all times, welcome criticisms of existing methods and suggestions for improvements or new methods.

REPORT OF SUB-COMMITTEE 8—PETROLEUM WAXES.

The personnel of Sub-Committee 8 is as follows :—

SUB-COMMITTEE 8.

W. J. Wilson (*Chairman*) (Burmah Oil Co., Ltd.).
J. Cantor (Shell Refining and Marketing Co., Ltd.).
C. G. Gray (Asiatic Petroleum Co., Ltd.).
W. G. Leach (British Waxed Wrappings, Ltd.).
S. T. Minchin (Burmah Oil Co., Ltd.).
C. E. Mold (Price's Patent Candle Co., Ltd.).
W. B. Peutherer (alternate W. R. Guy) (Scottish Oils, Ltd.).
V. L. Shatwell (Chiswick Products, Ltd.).
A. R. Stark (Anglo-Iranian Oil Co., Ltd.).
W. H. Thomas (alternate F. W. H. Mathers) (Anglo-Iranian Oil Co., Ltd.).
T. C. G. Thorpe (Petroleum Board).

Nomenclature Panel.

J. Cantor (*Chairman*) (Shell Refining and Marketing Co., Ltd.).
S. T. Minchin (Burmah Oil Co., Ltd.).
V. L. Shatwell (Chiswick Products, Ltd.).
T. C. G. Thorpe (Anglo-American Oil Co., Ltd.).

The scope of the work of this Sub-Committee is comparatively small, for although the petroleum waxes are products of considerable importance, accepted methods of test in connection with it are few. It is known, however, that certain test methods have been developed which have not yet been published, and the attention of the Sub-Committee will be directed to such methods as they become available.

During the past year the designation of the Sub-Committee has been changed from " Paraffin Wax " to " Petroleum Waxes." The broader

title has become necessary because of the increasing commercial production and utilization of waxes which, while they are derived from petroleum, yet differ considerably from the product known as "Paraffin" or "Paraffin Wax."

"Setting Point" and "Congealing Point."

The "Setting Point" method of test is one which has, with occasional modifications, been a standard method for many years. The method was devised for paraffin waxes and scales only, but some time ago a modified procedure was incorporated in the text which was designed to make the method applicable also to other petroleum waxes. Actually the modification did not ensure a result being obtained from all types of petroleum waxes, and the Sub-Committee this year, in reconsidering the position, decided that the petroleum waxes other than paraffin wax require to be considered entirely separately from paraffin wax with regard to the determination of a temperature representing the change from the liquid to the solid phase, or vice versa. Certain existing standard methods, *e.g.*, A.S.T.M. D.127–30—Melting Point of Petrolatum and I.P. 31/42—Drop Point of Greases, Petrolatum and Asphaltic Bitumen, were possible bases for the formulation of the desired new standard method. Other proposals were considered, and ultimately, after some co-operative experimental work had been done, a new tentative standard method was adopted, termed the "Congealing Point" method. This simple method is an adaptation of a test which has had occasional use in a number of laboratories in the past.

Colour.

Some minor modifications have been made in the method (I.P. 17/42) for measurement of the colour of waxes. It is felt that the art of colour measurement, in relation to waxes and oils, requires further development, and further consideration will be given to this subject.

Oil Content.

A method for determination of the oil content of wax (*i.e.*, that proportion of the product which exists in the liquid state at a specified temperature), reasonably simple and accurate, has long been the quest of many experimenters. While a few methods have been published and others have been employed in individual laboratories, none appears to have won general approval. It was inevitable that this subject should engage the attention of the Sub-Committee, especially as a newly published method had received the endorsement of A.S.T.M. The Sub-Committee did not feel able to recommend, at the present stage, the adoption of this or any other method. The subject continues under periodic review.

Nomenclature Panel.

In the course of discussions it became evident that the nomenclature of petroleum waxes and intermediate products was in a state of some confusion. The Sub-Committee was persuaded that an attempt ought to be made to deal with this difficult matter. A panel was constituted for this purpose, and its report was accepted by the Sub-Committee and has been published in the *Journal*.*

* *J. Inst. Petrol.*, Dec. 1943, **29** (240), 361.

REPORT OF SUB-COMMITTEE NO. 9—DERIVED CHEMICALS.

Origin and Scope of Committee.

Towards the end of 1942 it was felt by the I.P. Standardization Committee that I.P. " Standard Methods " should include methods of analysing the various chemical products derived from petroleum now coming into widespread industrial use. A Committee was accordingly set up under the chairmanship of the writer, the decision as to the range of products to be covered being left to the Committee. The Committee and Panel membership was :—

Sub-Committee 9.

J. A. Oriel (*Chairman*) (Asiatic Petroleum Co., Ltd.).
L. J. Bellamy (Ministry of Supply).
E. J. Boorman (Government Laboratory).
W. E. J. Broom (Esso European Laboratories).
L. W. Chubb (Technical Products, Ltd.).
E. A. Coulson (Department of Scientific and Industrial Research).
C. L. Gilbert (Asiatic Petroleum Co., Ltd.).
E. M. W. Fawcett (Anglo-Iranian Oil Co., Ltd.).
D. Morten (Shell Refining and Marketing Co., Ltd.).
A. R. Stark (Anglo-Iranian Oil Co., Ltd.).
W. H. Thomas (Anglo-Iranian Oil Co., Ltd.).

Physical Tests Panel.

W. E. J. Broom (*Chairman*) (Esso European Laboratories).
E. J. Boorman (Government Laboratory).

Chemical Tests Panel.

W. H. Thomas (*Chairman*) (Anglo-Iranian Oil Co., Ltd.).
E. A. Coulson (Department of Scientific and Industrial Research).

Technological Tests Panel.

L. W. Chubb (*Chairman*) (Technical Products, Ltd.).
E. M. W. Fawcett (Anglo-Iranian Oil Co., Ltd.).

In view of the great variety of chemical products available from petroleum, some difficulty was found in defining the term " derived chemicals," but it was eventually agreed that the Committee should consider all marketed products produced from petroleum which were not intended to be used directly as fuel or lubricants, with the exception of petroleum products such as asphalt, special boiling-point spirits, and waxes. To begin with, only products marketed or produced in the U.K. were to be considered. A rough classification of products was suggested in terms of : (1) Pure Chemicals and (2) Other Materials. The former category was taken to include : (*a*) carbon and hydrocarbons, (*b*) oxygen-containing derivatives of hydrocarbons, (*c*) halogen- and nitrogen-containing derivatives of hydrocarbons and (*d*) sulphur-containing derivatives of hydrocarbons. The second category included : petroleum resins and extracts, petroleum acids, sulphonic acids, phenols, synthetic detergents, etc.

It was, however, finally decided to classify the tests under the headings : (*a*) Physical, (*b*) Chemical, and (*c*) Technological tests. Panels were then set up to consider the most suitable tests of each type, and as a result the following methods were standardized :—

(There are, of course, many tests applicable to these materials which

are described for more general products. For example, it was not considered necessary to consider Specific Gravity, Boiling range, etc.)

(a) *Physical Tests.*—Mean molecular weight. Surface and Interfacial Tensions.

(b) *Chemical Tests.*—Naphthenic acids in soda neutralized oils, Iodine value, Peroxide value of ethers, Inorganic salts in petroleum detergents of the alkyl sulphate type, Alkalinity, Acetate content of solvents, Halogen content, Unsaponifiable matter in drying oils.

(c) *Technological Tests.*—Residual odour of lacquer solvents, Wetting power of wetting agents derived from petroleum, Drying time of Aromatic Petroleum Extracts.

Additions have also been made to the Union Colorimeter Test, to cover the testing of petroleum extracts, and to the distillation test, to cover the necessity for testing for peroxides before carrying out a distillation on ethers.

Work in Hand.

In addition to the above tests, an attempt has been made to standardize a suitable relative evaporation test for the examination of solvents to be used in the paint and lacquer industry. From contact with Paint Research Stations and industrial firms, it appears that no suitable well-recognized test is in existence. Those that are actually used are either simple rule-of-thumb tests or require complicated apparatus and are not suitable for routine work. As it is generally agreed that such a test is of value in assessing the behaviour of solvents, advice on the methods used in the U.S.A. was sought from the A.S.T.M., but so far the appropriate committee of that body is taking no steps to standardize a test, as they have not been asked to do so by their members. In the meantime a search is being made of the literature available on the subject, so that the significance of any method can be fully appreciated.

Contacts with Other Committees.

Contact is being maintained with the Methods Sub-Committee of the Extracts Pool Technical Panel, and a brief report on the progress of our work on this side has been sent to the Secretary of Committee D.2 of the A.S.T.M. Partly as a result of our contact with the A.S.T.M., the latter have decided to organize a new Committee which will deal with a limited selection of derived chemical products.

Future Work.

The Committee appreciates that only a relatively small start has been made with the methods which will eventually be required for the testing of these products, and will add to the number of methods as the need for them arises and suitable methods are worked out.

REPORT OF SUB-COMMITTEE NO. 10—APPARATUS.

The following Apparatus Sub-Committee has been set up to maintain uniformity throughout the various sub-committees in matters concerning apparatus and equipment.

SUB-COMMITTEE 10.

J. S. Jackson (*Chairman*) (Asiatic Petroleum Co., Ltd.).
J. E. C. Bailey (alternate I. C. P. Smith) (Scientific Instrument Manufacturers Association).
A. E. Calderara (British Lampblown Scientific Glassware Association).
J. C. Cragg (C. C. Wakefield & Co., Ltd.).
S. J. Davies (British Laboratory Ware Manufacturers Association).
J. A. Hall (National Physical Laboratory).
H. Hyams (Asiatic Petroleum Co., Ltd.).
M. M. Lapitzky (Shell Refining and Marketing Co., Ltd.).
J. Mason (Ministry of Aircraft Production).
A. Osborn (Esso European Laboratories).
W. H. Thomas (Anglo-Iranian Oil Co., Ltd.).

It will be seen that this Committee has been fortunate in securing the co-operation of the principal trade associations concerned, and there is every hope that all apparatus specified in "Standard Methods" will ultimately meet with the approval of both the user and the manufacturer. The present arrangement has the great advantage that the manufacturers have ample warning of impending changes, and are therefore in a favourable position to meet their customers' requirements without either inconvenience to the customer or loss to the supplier.

The Sub-Committee's first task was to reconsider the whole of the existing thermometer specifications. These have been extended to include a number of new thermometers, and a complete schedule of new war-time specifications has already been published in the *Journal*. In preparing this schedule special efforts were made to make the best possible use of the limited skilled labour and specialized materials available in war-time. It should be emphasized, however, that the effective co-operation of the manufacturers' representatives has ensured that the simplifications which have been effected have not resulted in any loss of accuracy or workmanship. In fact, it is confidently expected that the new thermometers will not only be easier to make, but actually more satisfactory in use, and the war-time schedule can obviously become the basis of normal peace-time production with the minimum amount of modification.

The hydrometer specifications have also been simplified very considerably, and a complete set of war-time specifications has been published.

Hydrometers constitute a special case presenting peculiar difficulties, and these war-time specifications call for some brief explanation. It was generally agreed that circumstances did not warrant any relaxation of the accuracy requirements. In fact, it was felt that greater accuracy was required and could reasonably be specified. On the other hand, the close dimensional requirements of the pre-war 1942 specifications have caused practical manufacturing difficulties, with resultant restriction of output. It was therefore decided, after due consideration of all the factors, to compromise between the previous I.P. practice of specifying closely all critical dimensions and the A.S.T.M. practice of concentrating upon the required accuracy. Thus, the war-time hydrometer specifications will specify only (1) accuracy, (2) overall length, and (3) length of scale, in addition, of course, to the usual general clauses. Bulb and stem dimensions, etc., are set out merely to indicate to the manufacturer the type of instruments required, and these dimensions will not be obligatory.

The reconsideration of the thermometer and hydrometer specifications

has consumed much time, and so far it has not been possible to give detailed attention to more than a few of the general apparatus questions, but a number of outstanding difficulties have been dealt with. Thus, an improved specification for the Ramsbottom coking bulb and its metal sheath will appear in the new edition, whilst the use of a straight-necked Redwood viscosity flask is permitted as well as the fragile Kohlrausch type.

In connection with the penetration test, the A.S.T.M. needle has now been specified. This incidentally is in accordance with the desire of the Institute to co-operate as closely as possible with the A.S.T.M. Similarly, the B.S.I. specification for the Drop Point apparatus has been accepted. These changes will, of course, facilitate production, since only one specification will exist in each case, instead of two.

The Committee has made excellent progress, and it constitutes in a small way an interesting example of the useful results that can be obtained when supplier and user meet and really understand and appreciate each other's requirements and difficulties.

The future work of the Committee must depend largely on the activities of the other Committees, but a number of points have already accumulated, and doubtless, now that the Committee is actively operating, suppliers and users will bring forward their difficulties and suggestions.

PRACTICAL ALIGNMENT CHART FOR FLUID FLOW IN PIPE-LINES.*

By Percy Meyer.

Where a calculation employing simple multiplication or division is required, the advantage of an alignment chart over long-hand working or slide-rule reckoning is questionable. On the other hand, when an equation contains a variety of fractional powers then an alignment chart can be quicker, and to the extent that it avoids any ambiguity in the decimal point, it can be more accurate. The first feature of this alignment chart therefore is that the number of scales and the variety of units used have been kept to a minimum.

Fluid flow is a subject which from the fundamental viewpoint is best handled with self-consistent units giving dimensionless terms. However, in practice one deals in common engineering units, and the second feature of the chart is to avoid the need for interconversion of units.

A third feature is that the use of the chart assumes no prior knowledge of whether the flow is turbulent or streamline. Apart from pressure drop calculations, the chart is useful in ascertaining whether an orifice in the line will be outside the streamline flow region and thus give the usual metering accuracy associated with turbulent flow.

Regarding the units chosen, the use of "feet head of flowing fluid" is not very practicable for gases, and accordingly pounds per square inch have been used. Similarly the cubic foot is a satisfactory measure of volume for both liquids and gases and therefore preferable to the gallon. The viscosity of liquids, generally speaking, covers a much wider range of values than that of gases, and the majority of viscometers in use for liquid testing give a flow time which is directly convertible to the common unit of kinematic viscosity, the centistoke.

The established relationship for fluid flow in pipe-lines is :

$$Q = 34{\cdot}5\sqrt{\frac{D^5P}{GLF}}$$

where Q = cubic feet per hour flowing fluid.
D = actual pipe diameter in inches.
P = pressure drop, lb. per sq. in., between inlet and outlet.
G = specific gravity or density of flowing fluid (water 1·0).
L = length of pipe-line in feet.
F = the Fanning friction factor.

To ascertain the value of F, it is generally necessary to calculate the Reynolds number, which includes the effect of viscosity, and to look up a graphical correlation of F with the Reynolds number. In this alignment chart, the right-hand-side deals with the flow equation above, in terms of Q, D, and P/GLF. Passing through the reference axis and the viscosity

* Reprinted by kind permission of "Canadian Chemistry and Process Industries."

scale gives the value of F for clean commercial pipe. Above the value $F = 0{\cdot}011$ the flow is streamline, and below this region it becomes turbulent, tending to approach the value of 0·005 and rarely falling below this. (Actually the reference axis is a scale of Q/D, algebraically equivalent to the product of linear flow velocity times pipe diameter: this, divided by the kinematic viscosity, gives the Reynolds number. These intermediate values do not enter into the final computation and hence the scales do not need these calibrations.)

For gas flow, the pressure drop may be large and the volume of gas may expand considerably under flow conditions. The formula generally used is of the type:

$$Q = \text{Constant} \sqrt{\frac{D^5(P_1^2 - P_2^2)}{GTLF}}$$

where Q is defined under standard conditions (60° F. and 14·7 lb. sq. in. for instance), G is the gas specific gravity or density standardized under the same conditions, P_1 and P_2 are the inlet and outlet pressures in lb. sq. in. absolute, and T is the absolute temperature.

However, $(P_1^2 - P_2^2)$ factorizes as $(P_1 - P_2)(P_1 + P_2)$, in which the first term represents pressure drop while the second term is twice the arithmetic average pressure. In deriving this equation the usual gas laws have been assumed whereby the flowing volume and flowing density of a gas depend upon the flowing pressure. By using Q and G in terms of arithmetic-average flowing volume and flowing density, and referring the flowing gas density to water as unity, the general fluid-flow equation as originally stated is precisely applicable to high-pressure gas flow, giving a result mathematically identical with that from the more elaborate equation using the $(P_1^2 - P_2^2)$ term.

Example 1.—What pressure is required to force 600 cu. ft. per hour of liquid through 500 feet of 2 inch pipe? The fluid is of 10 centistokes viscosity and 1·1 sp. gr. at flow temperature.

Answer: Drawing a straight line through the 600-cu.-ft. and 2-inch points, gives P/GLF as 9·1. Hence $P = 9{\cdot}1GLF$. This straight line is also drawn to intersect the reference axis. Proceeding from this point of intersection through the 10-centistoke point gives F as 0·0083.

$$\text{Hence } P = 9{\cdot}1 \times 1{\cdot}1 \times 500 \times 0{\cdot}0083.$$
$$= 42 \text{ lb. per sq. in}$$

This is, of course, the dynamic pressure drop assuming a horizontal pipe-line; if the discharge level is above or below the inlet level, the usual static-head correction has to be applied.

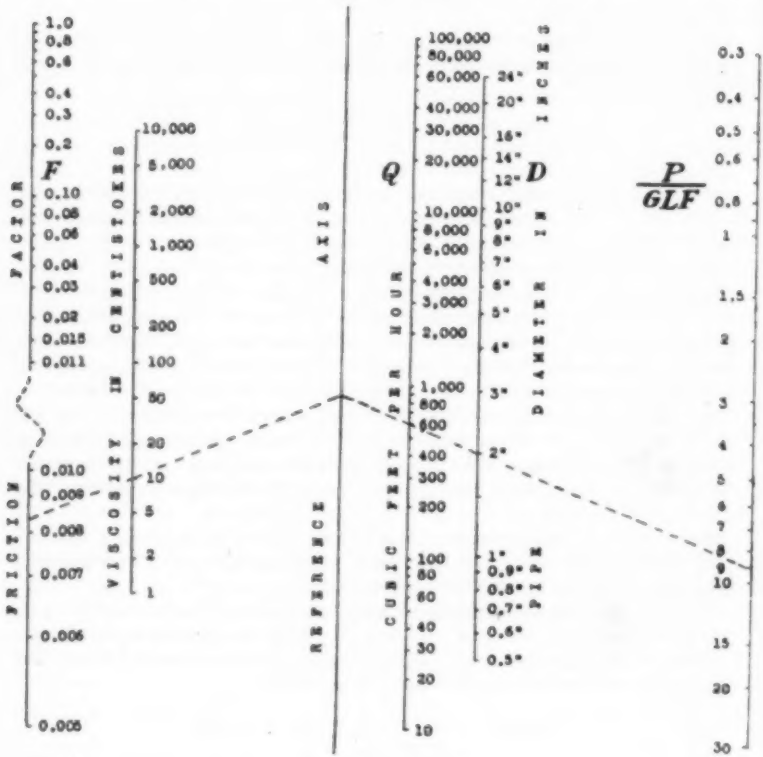
Example 2.—The above line delivers into a 4-inch line in which it is proposed to install an orifice for measuring the quantity flowing. Will the meter give accurate measurement?

Answer: The F point falls between 0·010 and 0·011, that is, where the flow may be either turbulent or streamline. It would be better to put the orifice in the 2 inch line.

Example 3.—What diameter pipe-line is required to deliver 10,000 cu. ft. per hour (measured at 60° F. and 14·7 lb. per sq. in.) of nitrogen a

distance of three miles? Assume average atmospheric temperature, and an available inlet pressure of 95 lb. per sq. in gauge, with discharge pressure to be above 5 lb. per sq. in. gauge.

Answer: The probability is that the smallest calculated diameter will include an odd fraction and will not be matched by a standard size. Therefore the nearest larger standard size would be used in practice. Hence



269

the discharge pressure would be higher than the specified minimum 5 lb.: it would be (for trial) 25 lb. say; giving an *average* line pressure between 95 lb. inlet and 25 lb. outlet, of 60 lb. gauge or 75 lb. absolute, *i.e.*, five atmospheres.

Under this pressure the 10,000 cu. ft. per hour will average about 2,000 flowing cubic feet per hour. Aligning this point with a trial 4-inch diameter pipe, gives $P = 3{\cdot}2GLF$.

G for nitrogen under atmospheric temperature and pressure is about

0·0012 : under five atmospheres it will be about 0·006. Thus with L at 15,800 ft.

$$P = 3{\cdot}2 \times 0{\cdot}006 \times 15{,}800 \times F$$
$$= 300 \times F.$$

Regarding the value of F, for rapid approximate work it is worth noting that gas flow in pipe-lines falls in most practical cases in the turbulent flow region, limiting F to the range 0·005–0·010; where a large error in the assumed viscosity makes a relatively small difference to F; also that the range of values for gas viscosity, except at extremes of temperature and pressure, is relatively small, *e.g.* :

	At 0° C.	At 300° C.
Hydrogen	0·008	0·014
Nitrogen	0·017	0·028
Oxygen	0·019	0·034
Mercury	—	0·054

centipoises

In practice, taking F at the upper value of 0·010 for turbulent flow in clean pipe will give a factor of safety. However, a check on flow conditions is desirable and is readily carried out.

Taking the viscosity of nitrogen as 0·018 centipoises, dividing by the flowing density of 0·006 gives the kinematic viscosity as 3 centistokes. Hence F is about 0·0055 and

$$P = 300 \times F$$
$$= 300 \times 0{\cdot}0055$$
$$= 1{\cdot}65 \text{ lb. per sq. in.}$$

The outlet pressure from the 4-inch line would be only 1·65 lb. below the inlet pressure : clearly this diameter is unnecessarily large.

Trying a 2-inch line : for 2,000 flowing cubic feet and a 2-inch line the value of P/GLF is off the scale ; but as this value is 3·2 for a 4-inch and is dependent on the fifth power of the diameter it will be $(4/2)^5$ equals thirty-two times as great, *i.e.*, 32 times 3·2 or, say, 100 for a 2-inch line. F becomes about 0·005. Hence

$$P = 100 \times 0{\cdot}006 \times 0{\cdot}005 \times 15{,}800$$
$$= 47 \text{ lb. per sq. in.}$$

With an inlet pressure of 95 lb. per sq. in. gauge, a drop of 47 gives an outlet pressure of 48 lbs. per sq. in. gauge, which is somewhat higher than required.

Trying 1½-inch-diameter line : the ratio of diameters to the fifth power $(2{\cdot}0/1{\cdot}5)^5 = 4{\cdot}2$, indicates that the pressure drop will be of the order of 4 times the 47 lb. above, *i.e.*, much higher than the available 90 lb. (It will be observed that the pressure drop rises very steeply as the line gets smaller).

A 2-inch line is the nearest practicable diameter.

The usual allowance for bends, elbows, valves, etc., in the line can be included by adding the " equivalent length of pipe." A rough pipe surface,

except in so far as it may reduce the effective pipe diameter, does not affect pressure drop in the viscous or streamline flow region, but it causes an increase in the turbulent flow region. Where this condition is expected, a factor of safety may be introduced by taking F at the lowest value for streamline flow and the highest value for turbulent flow—*i.e.*, at about 0·011, even if the flow is indicated to be turbulent. Additionally it is important that the actual effective pipe diameter be used, and not the nominal one; particularly is this true of small-bore pipes.